

REMARKS

The present invention is a speaker and an electronic device utilizing the speaker in accordance with the invention. In accordance with an embodiment of the invention, a speaker comprises first and second diaphragms 22 and 23 enclosing a cavity as illustrated in Figs. 5-7 arranged to be driven in opposite phase with respect to one another to cause the diaphragms to move in a same direction as illustrated in Figs. 6 and 7 so that the volume of the cavity remains substantially constant.

Claims 1-2, 6-7, 9, 11-12, and 14 stand rejected under 35 U.S.C. §102 as being anticipated by United States Patent 6,023,123 (Petiet). This ground of rejection is traversed for the following reasons. Claim 1 recites a speaker comprising first and second diaphragms enclosing a cavity and being arranged to be driven in opposite phase with respect to one another to cause the diaphragms to move in a same direction so that a volume of the cavity remains substantially constant and claim 11 recites a speaker comprising first and second opposed diaphragms enclosing a cavity and the diaphragms being arranged to be driven so that, in use, they move in the same direction with respect to one another so that a volume of the cavity remains substantially constant. This subject matter has no counterpart in Petiet.

Petiet discloses a system in which two parallel window panes either repel or attract one another depending on the signal shape applied thereto. See column 1, lines 58-67. As is apparent from the foregoing description with respect to claim 1, the diaphragms are not arranged to be driven in opposite phase with respect to one another to cause the diaphragms to move in a single direction so that a volume of the cavity remains substantially constant and with respect to claim 11, the

diaphragms are not arranged be driven so that in use they move in the same direction with respect to one another so that a volume of the cavity remains substantially constant. As a person of ordinary skill in the art understands from reading Petiet, the application of signals in phase causes window panes to either repel or attract one another which results in movement in different directions and the volume of the cavity does not remaining substantially constant as recited in independent claims 1 and 11.

Moreover, there is no basis in the record why a person of ordinary skill in the art would be led to modify the teachings of Petiet to arrive at the subject matter of independent claims 1 and 11 nor the dependent claims since Petiet operates in a different manner to that defined by the independent claims.

Claims 1-3, 6-7, 11-12 stand rejected under 35 U.S.C. §102 as being anticipated by United States Patent 5,185,549 (Sullivan). This ground of rejection is traversed for the following reasons.

Sullivan discloses the utilization of films which are elongated as the result of electric fields which causes the outer surfaces of the films to oscillate in phase and thereby displace air located between the outer surfaces of the films. See column 2, lines 14-20. Moreover, as is taught in column 23, lines 2-15, the two piezo-electric films 12 are mounted such that they will expand towards one another simultaneously and contract away from one another simultaneously in response to the electric signal. Accordingly, Sullivan does not teach, as recited in claim 1, first and second diagrams enclosing a cavity and being arranged to be driven in opposite phase with respect to one another to cause the diaphragms to move in a same direction so that a volume of the cavity remains substantially constant and, as recited in claim 11, first

and second opposed diaphragms enclosing a cavity and the diaphragms being arranged to be driven so that, in use, the diaphragms move in the same direction with respect to one another so that a volume of the cavity remains substantially constant.

Moreover, Sullivan does not disclose the subject matter of dependent claims 2, 3, 6-7 and 12.

Moreover, there is no basis in the record why a person of ordinary skill in the art would be led to modify the teachings of Sullivan to arrive at the subject matter of the rejected claims.

Claims 20-25 and 27-28 stand rejected under 35 U.S.C. §102 as being anticipated by United States Patent 4,352,961 (Kumada et al). This ground of rejection is traversed for the following reasons.

Claim 20 recites an electronic device including a display in a transparent speaker, the speaker being mounted in front of the display so that the display is visible through the speaker wherein the speaker is in accordance with claim 1. Kumada et al teach a piezo-electric bimorph drive plate fitted in a casing 4 with a packing 3 interposed therebetween. The driver is constructed of transparent plates 11 and 12 made of a ceramic piezo-electric material with transparent electrodes 20, 21 and 22 being in contact therewith. This subject matter does not meet the subject matter of claim 20 which is dependent on claim 1 nor the subject matter of dependent claims 21-25 and 27-28. Moreover, there is no basis in the record why a person of ordinary skill in the art would be led to modify the teachings of Kumada et al to arrive at the subject matter of the rejected claims.

Claims 20-24 and 28 stand rejected under 35 U.S.C. §102 as being anticipated by United States Patent 6,427,017 (Toki). Toki describes a piezo-electric diaphragm with a transparent piezo-electric member which may be placed in front of a cathode ray display as illustrated in Fig. 5. However, Toki does not disclose the subject matter of claim 1. Moreover, Toki does not disclose the subject matter of dependent claims 21-24 and 18. Moreover, there is no basis in the record why a person of ordinary skill in the art would be led to arrive at the subject matter of the rejected claims.

Claims 4-5 stand rejected under 35 U.S.C. §103 as being unpatentable over Petiet or Sullivan. This ground of rejection is traversed for the following reasons.

The Examiner has taken official notice that providing the piezo-electric film and a loudspeaker comprising PVDF material and an ITO coating is well known in the art. However, the deficiencies noted above with respect to Petiet and Sullivan are not cured by the Examiner's official notice. Moreover, it is submitted that a person of ordinary skill in the art would not consider what the Examiner contends to be well known in the art, if true, to cure the deficiencies noted above with respect to Petiet and Sullivan.

Claims 8, 10, 13 and 15 stand rejected under 35 U.S.C. §103 as being unpatentable over Petiet. This ground of rejection is traversed for the following reasons.

The Examiner reasons "it would have been obvious to one skilled in the art to provide any volume of the cavity (18) of Petiet such as providing a volume of the cavity (18) that remains substantially constant for better controlling the vibrations of the diaphragms (1, 2) and better producing an anti-sound signal to the system." This

reasoning is totally unsupported by the citation of prior art and is traversed since the Examiner has not demonstrated on the record any teachings which would render obvious what the Examiner contends to be obvious with respect to claim 8.

With respect to claims 10 and 15, the Examiner reasons the Petiet does not specifically teach the claimed gas. However, the Examiner goes on to argue that it would be obvious to provide any type of gas, such as sulphur tetrafluoride for better controlling the pressure in the cavity (18) and the vibrations of the diaphragms (1, 2). The Examiner's rejection of claims 10 and 15 is unsubstantiated without the citation of any prior art suggesting the claimed sulphur tetrafluoride.

Claims 16-19 stand rejected under 35 U.S.C. §103 as being unpatentable over Toki or Kumada et al in view of Petiet. The deficiencies of Petiet, as discussed above with respect to the rejection of claim 1, are not addressed by Toki or Kumada et al. Accordingly, if the proposed combination of Toki or Kumada et al in view of Petiet was made, the subject matter of claims 16-19 would not be achieved.

Claim 26 stands rejected under 35 U.S.C. §103 as being unpatentable over Kumada et al. This ground of rejection is traversed for the following reasons.

Kumada et al do not disclose the subject matter of claim 1 in comprising first and second diaphragms enclosing a cavity and being arranged to be driven in opposite phase with respect to one another to cause the diaphragms to move in a same direction so that a volume of the cavity remains substantially constant. There is no basis in the record why a person of ordinary skill in the art would be led to modify the teachings of Kumada et al to arrive at the subject matter of claim 26.

Claims 25-27 stand rejected under 35 U.S.C. §103 as being unpatentable over Toki. This ground of rejection is traversed for the following reasons.

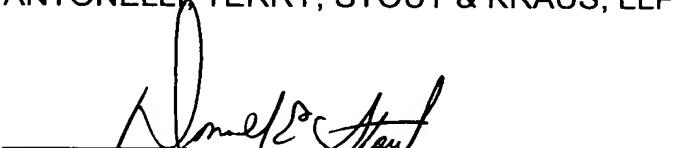
Toki does not disclose a speaker comprising a first and second diaphragms enclosing a cavity and being arranged to be driven in opposite phase with respect to one another to cause the diaphragms to move in a same direction so that a volume of the cavity remains substantially constant.

In view of the foregoing amendments and remarks, it is submitted that each of the claims in the application is in condition for allowance. Accordingly, early allowance thereof is respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 C.F.R. §1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (367.40314X00) and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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SUBSTITUTE SPECIFICATION

Dual Diaphragm Speaker

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to the field of speakers, particularly but not exclusively to a dual diaphragm piezo-electric speaker for an integrated hands-free portable communications device.

Background

Description of the Prior Art

[0002] Integrated hands free (II-IF) handsets are a relatively recent development in mobile telephone technology. As such handsets become lighter and more compact, there is an ever-increasing requirement for the size and weight of speakers to be reduced and for quality to be increased. This is especially so as speakers are used for polyphonic ringer melodies, downloaded midi music files, text-to-speech conversion, FM radio and so on. Efficiency is also an issue when trying to maximise maximize talk time with IHF speech.

[0003] Many different types of speaker are known, including a single diaphragm gas filled piezo-electric dome speaker, for example the Audax FTD-3P. Such speakers are prone to non-linearities and even harmonic distortion, for example due to the outward excursion of the speaker diaphragm being less than the inwards excursion for a given voltage. A single diaphragm speaker also suffers from the drawback that the gas acts as a non-linear spring, providing a stiffness which varies with volume.

The present invention aims to address the above problems.

Summary of the Invention

[0004] The present invention addresses the above problems of the prior art.

[0005] According to the present invention, there is provided a speaker comprising first and second diaphragms arranged to be driven in opposite phase with respect to one another.

[0006] Advantageously, the dual diaphragm arrangement provides for the cancellation of even harmonic distortion since the harmonic distortion produced by the expansion of one diaphragm is cancelled by the corresponding contraction of the other and vice-versa.

[0007] The speaker can be transparent and can be arranged to be located over the display, so that the display is visible through the speaker.

[0008] The invention also provides an electronic device including a display and a transparent speaker, the speaker being mounted in front of the display so that the display is visible through the speaker. The speaker can be any transparent speaker, including single diaphragm and dual diaphragm piezoelectric speakers.

[0009] As mobile devices perform more visual functions such as photography, GPS location, web browsing, personal digital assistance and so on, the display is likely to take up more of the available space, with consequential requirements on the speaker to be as small as possible. However, small speaker diaphragms have to move a greater distance than large ones to produce a given sound pressure level, which leads to greater distortion. Small speakers are also less efficient, which reduces talk time. By providing a transparent speaker which can be as large as the display area, a better quality speaker can be produced while minimising the demands on space within the device.

[0010] According to the invention, there is further provided a speaker comprising first and second opposed diaphragms, the diaphragms being arranged to be driven so that, in use, they move in the same direction with respect to one another.

[0011] The space between the diaphragms can be filled with a gas having a large molecular size, to prevent leakage. Since the volume of gas between the diaphragms remains substantially constant as they move in the same direction, this removes a potential source of non-linearity with respect to a speaker in which a single diaphragm moves relative to a fixed backplate.

Brief Description of the Drawings

[0012] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

[0013] Figure 1 is a perspective view of a mobile telephone handset;

[0014] Figure 2 is a simplified schematic cross-sectional view of the handset shown in Figure 1 illustrating the position of a dual diaphragm speaker according to the invention;

[0015] Figure 3 is a schematic diagram of mobile telephone circuitry for use in the telephone handset of Figure 1;

[0016] Figure 4 is a schematic front view of a dual diaphragm speaker according to the invention;

[0017] Figure 5 is a schematic cross-sectional view of the dual diaphragm speaker of Figure 4;

[0018] Figure 6 is a schematic cross-sectional view of the dual diaphragm speaker with a first input polarity; and

[0019] Figure 7 is a schematic cross-sectional view of the dual diaphragm speaker with a second input polarity.

Detailed Description

DETAILED DESCRIPTION OF THE INVENTION

[0020] Referring to Figures 1 and 2, a mobile station in the form of a mobile telephone handset 1 includes a microphone 2, keypad 3, with a hands-free mode selection key 4, an LCD display 5, an earphone speaker 6, a hands-free speaker 7 and an internal antenna 8 (not shown). The hands-free speaker 7 is a transparent speaker located between the display 5, which is mounted to the handset's PCB 9, and the front cover of the handset 10. The space 11 between the speaker 7 and the display 5 acts as an acoustic cavity and can include a reflex port (not shown), for example to improve performance for mid-range use.

[0021] The mobile station 1 is operable to communicate through cellular radio links with individual PLMNs (public land mobile network) shown schematically as PLMN A, for example a GSM 1800 MHz network.

[0022] Figure 3 illustrates the major circuit components of the telephone handset 1. Signal processing is carried out under the control of a digital micro-controller 12 which has an associated flash memory 13. Electrical analogue-analog audio signals are produced by microphone 2 and amplified by pre-amplifier 14. Similarly, analogue-analog audio signals are fed to the speakers 6, 7 through respective amplifiers 15, 16. The amplifier 16 for the hands-free speaker 7 is, for example, a digital class D amplifier. The micro-controller 12 receives instruction signals from the keypad 3 and hands-free mode selection key 4 and controls

operation of the LCD display 5. The hands-free mode selection key 4 is used to instruct the micro-controller 12 to switch between the earphone speaker 6 and the hands-free speaker 7.

[0023] Information concerning the identity of the user is held on a smart card 17 in the form of a GSM SIM card which contains the usual GSM international mobile subscriber identity (IMSI) and an encryption key K₁ that is used for encoding the radio transmission in a manner well known per se. The SIM card is removably received in a SIM card reader 18.

[0024] The mobile telephone circuitry includes a codec 19 and an rf stage 20 feeding the antenna 8.

[0025] Referring to Figures 4 and 5, a dual diaphragm speaker 21 according to the invention comprises first and second diaphragms 22, 23 mounted to an insulating support frame 24. Each diaphragm 22, 23 comprises a transparent piezo-electric polymer film 25, for example a 6~μm thick film of polyvinylidene fluoride (PVDF), which is coated on its inner and outer surfaces 26, 27 with a transparent conductive material, for example indium tin oxide (ITO), to form inner and outer electrodes. The cavity 28 between the diaphragms 22, 23 is filled with a gas with a large molecular size, to prevent it escaping through the diaphragms, for example, sulphur tetrafluoride SF₄. The gas pressure is arranged to keep the diaphragms in tension, so that they form a dual dome shape.

[0026] The inner and outer electrodes 26, 27 of each diaphragm are connected to the output of the amplifier 16 so that a first input terminal 29 is connected to the outer coating 27 of the first diaphragm 22 and an inner coating 26 of the second diaphragm 23, while a second input terminal 30 is connected to the inner coating 26 of the first diaphragm 22 and an outer coating 27 of the second diaphragm 23.

[0027] The operation of the dual diaphragm speaker will now be described with reference to Figures 5, 6 and 7. When a driving voltage of a first, for example, a

positive polarity is applied to the input terminals 29, 30 from the amplifier 16, the first diaphragm 22 contracts as a result of the piezo-electric effect. At the same time, as a result of the electrode connections described above, the polarity of the electrodes 29, 30 of the second diaphragm 23 are reversed with respect to those of the first diaphragm 22. The second diaphragm 23 therefore expands as a result of the piezoelectric effect. The result is that both diaphragms move in the same direction, as shown in Figure 6. Similarly, when the opposite polarity is applied to the input terminals 29, 30, the first diaphragm 22 elongates and the second diaphragm 23 contracts, so that both diaphragms again move in the same direction, being the opposite direction to that shown in Figure 6, as illustrated in Figure 7.

[0028] Therefore, as described in detail above, when the diaphragms 22, 23 are driven in opposite phase, both move in the same direction like a single diaphragm. As a result of the push-pull configuration, non-linearities due to the amount of expansion being greater or less than the amount of shrinkage for a given voltage, are effectively cancelled. Furthermore, the volume of gas between the diaphragms 22, 23 stays substantially constant during the excursions of the diaphragms, so that the tension of the diaphragms remains substantially constant. This removes another potential source of non-linearity with respect to a single diaphragm speaker. Since the volume of gas remains approximately the same during diaphragm excursions, the gas provides no stiffness, so that the speaker has a lower resonant frequency than a corresponding single diaphragm speaker and can be used over a wider frequency range.

[0028] [0029] While the invention has been primarily described with reference to a dual diaphragm speaker, other types of speaker can be mounted in front of the display 5 of a portable electronic device such as a mobile telephone or portable digital assistant, as long as they enable the display to be viewed through the speaker.

[0030] It will be appreciated by the skilled person that the speaker need not be limited to the rectangular shape and dimensions illustrated, but can be in the form of a convex lens or any other size or shape which is required to fit a particular device.

[0031] While the invention has primarily been described for use in a mobile telephone, it is also suitable for other types of portable electronic devices as well as for nonportable devices such as domestic speakers.

Abstract

Dual Diaphragm Speaker

A dual diaphragm speaker comprising first and second diaphragms operating in accordance with the piezoelectric effect, the diaphragms being arranged to be driven in opposite phase with respect to one another so as to cancel out non-linearities. The speaker is made transparent and mounted over the display panel of a mobile telephone.